Little Engines that Could: *Computing in Small Energetic Countries*

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How do very small countries, here defined as having fewer than 10 million people, find places for themselves in the information technologies (IT) arena? Does success require accommodation in the global IT regime that often seems dominated by the U.S. and Japan? Do the little countries scurry around, like birds among the lions and other predators looking for scraps? Are they relegated to second tier "appropriate technologies," or do they operate in the mainstream?

There are a surprising number of little countries around the world whose development of, and uses for, IT are out of proportion to their sizes and natural resource endowments. Their national circumstances and IT activities are as diverse as their geographic distribution.

The Major Minors

Several small countries have become major IT producers or sophisticated users. These include the city-states of Singapore and Hong Kong, Ireland, Israel, New Zealand and most Nordic nations (Table 1).

Singapore (2.8 million people) and Hong Kong (5.8 million) have high levels of hardware production, exports and advanced information infrastructures. Hardly twins, their differences are as striking as their similarities. Both have succeeded as hosts for foreign investment and as export platforms for multinational cor-

porations (MNCs). However, while Singapore has been able to upgrade its level of technology in response to rising wages and competition from low-wage countries, Hong Kong has responded by moving low wage production into nearby southern China. As a result, Singapore's higher-end IT production has continued to grow in recent years reaching $10.9 billion in 1993, while Hong Kong's production has stagnated since the late-1980s, standing at $2.3 billion in 1993 and still consists mostly of simple assembly [3].

Part of the reason for this divergence is the Singaporean government's efforts to train IT professionals and to encourage MNCs to locate advanced manufacturing activities there. Singapore has not only become the world's largest producer of hard disk drives, but also plays an integral role in the products development and manufacturing process. A typical hard disk life cycle starts with a design and prototype in the U.S. Then the first-generation production, including the critical ramping-up process, is done in Singapore. Once manufacturing is routinized, production is moved to a low-wage assembly site such as Indonesia or Malaysia, while the factory in Singapore begins work on the next generation. Singapore's ability to play such a critical role in the process is based on its strong capabilities in engineering and production management, and on its strong telecommunications infrastructure. The MNCs are further supported by many domestic contractors who supply components to specifications.

Singapore has applied IT in a number of other areas. Through the efforts of its National Computer Board, Singapore has computerized its public sector to make government more effective and responsive to the needs of business [5]. It has also established Tradenet, an electronic data interchange (EDI) system linking port facilities, government offices and private trading companies to improve the speed with which goods can pass through the Port of Singapore. Although its IT industry is heavily dependent on production by MNCs, two of its domestic companies control 75% of the sound card market.

Hong Kong has a different niche in the IT industry [7]. While much of its manufacturing is moving to China, Hong Kong has remained a site for management and trading services. Using its geographic location and ties to China, it has served as a link between southern China's IT industry and the outside world. Hong Kong's business skills and familiarity with the western economic system, combined with excellent port and telecommunications facilities, have allowed it to continue to play a role in the IT industry. It has also become a center for production of portable communications devices, partly due to its own extremely widespread use of cellular phones.

Hong Kong's banking and finance companies are highly sophisticated users of IT. Hong Kong is implementing an EDI system called Tradelink to maintain its competitive position as a trading port. Other trade organizations, such as the Hong Kong Air Cargo Terminal Ltd. are heavily automated. Overall, however, Hong Kong is still behind Singapore in IT investment, spending just 1.5% of its GDP on computer hardware, software and services, compared to Singapore's 2.2% (Table 1).

The Irish IT niche is one of "globalization from without" [4], with MNCs providing a high technology manufacturing component in IT and pharmaceuticals. Ireland's (3.5 million) advantages include skilled engineers, a low cost labor force compared to most of Western Europe, and an export platform for non-European MNCs into the European Community. Irish government policies are encouraging the development of IT-based infrastructure, with particular emphasis on getting services beyond Dublin. However, so far it lacks the extensive indigenous IT-using communities characterizing the other major minors.

Unlike Singapore, Hong Kong and Ireland, with clearly advantageous geographic locations, New Zealand (3.4 million) sits by itself in the middle of the South Pacific. Its economy still depends on agricultural exports, including wool and dairy products. In order to avoid being totally at the mercy of world commodities prices, its farmers and processing industries have used IT to add value to their products through product grading (e.g., a bar-coding system is used to sort wool by quality and track it from the sheep to the tailor). Other programs plan feeding, manage breeding and handle finances. These applications have been developed by local software firms and some are now exported [6]. New Zealand also developed a fourth-generation software language called LINC, and has services such as home shopping based on LINC software.

New Zealand's government introduced major reforms in the 1980s, with a number of state-owned enterprises being privatized. The largest was New Zealand Telecom, which was deregulated in 1988 and eventually sold to two U.S. Baby Bells, Ameritech and Bell Atlantic. Competition was also introduced into the telecommunications market. As a result, New Zealand now has a first-rate telecommunications infrastructure supporting advanced information services, such as the Tradegate EDI system and electronic funds transfer. The American owners of Telecom are said to use New Zealand as a test market, giving its people early access to new equipment and ser-

Table 1. IT Indicators

	Population (millions)	Phone lines per 1,000 people	MIPS* per 1,000 people	SW professionals per 1,000 people	HW production 1993 (U.S.$ mil.)	IT spending as % of GDP
Denmark	5.1	577	343	7.52	166	1.5
Finland	5.0	542	339	6.94	670	1.1
Hong Kong	5.8	448	159	NA	2306	1.5
Ireland	3.5	298	285	6.71	3729	NA
Israel	4.9	343	171	7.54	464	NA
New Zealand	3.4	439	302	7.21	38	2.7
Norway	4.3	515	357	7.40	335	1.5
Singapore	2.8	365	241	4.11	10933	2.2
Sweden	8.6	690	307	7.51	832	1.3
U.S.	252.5	552	673	7.93	49380	2.8
Japan	124.0	461	199	7.88	50939	1.6

*MIPS: million insctructions per second (installed computing capacity)

Sources: Elsevier, Yearbook of World Electronics Data, 1994; OECD, Information Technology Outlook, 1994; Juliessen and Juliessen, Computer Industry Almanac, 1994; Software Productivity Research Inc., 1994

vices. New Zealand's investment in IT was an extraordinary 2.7% of GDP in 1992 (Table 1).

Other advanced small countries include Israel (4.9 million), with world-class strengths in software, defense systems, telecommunications, and academic computer science [1]; and four Nordic countries: Denmark (5.1 million), Finland (5.0 million), Norway (4.3 million) and Sweden (8.6 million). All five are high per-capita users of IT. Finland is particularly noteworthy since historically it has been among the poorest of the Nordic countries, but now has one of the highest per-capita consumptions of IT in the world. It has its own multibillion dollar indigenous IT manufacturer in Nokia, which is second to Motorola as a world supplier of mobile phones and claims a 20% share of this market in Japan [2]. Sweden also is the home of a very large IT company for a small country—Ericsson in telecommunications and related technologies—and a fairly sophisticated defense industry. Denmark is moving along an IT path similar to New Zealand's. Norway has developed quality IT applications based on strengths in natural resources (e.g., fishing).

Different Strokes

Other small countries are finding a variety of IT niches in the world. These fall roughly into three categories: those which are essentially picking up fairly low-level, internationally distributed work; regional standouts; and those with dubious niches of opportunity.

Several countries are trying to use cheap labor and other incentives to attract low-level work from foreign MNCs. These activities differ from those in places like Singapore or Israel in that they involve relatively little technological input from off-shore workers, and not much IT is broadly infused into the local economies. Often work is in the form of off-shore data entry or manufacturing plants for well-established products. MNCs are taking advantage of cheap labor and improved telecommunications in the Caribbean area by setting up data-processing centers in several countries (e.g., AT&T spent $184 million to install a fiber cable linking Florida, Puerto Rico, the Dominican Republic (7.7 million) and Jamaica (2.5 million) [9]). Several companies have operations in Barbados (0.3 million), which is trying to make its keystroke "Information Services Industry" into a major economic sector. Costa Rica (3.3 million) is also in the data-entry business. All have advantages of cheap labor, geographic and time-zone proximity to North America and, in some cases, English as a spoken language.

Regional standouts are small countries that are simply doing better than their larger neighbors. These include Costa Rica, Slovenia (2 million), the Baltics (Estonia (1.6 million), Latvia (2.7 million) and Lithuania (3.8 million)), and Tunisia (8.6 million). Costa Rica is host to the regional offices of a number of MNCs, who bring advanced IT systems with them, giving local workers exposure to sophisticated applications. It has also been a regional leader in bringing international networking to Central America. Slovenia is a former-Yugoslavian country emphasising IT to help with the tasks of independent nation and economy building. It has been hosting MIS conferences, using computerized decision support and meeting systems, and infusing

IT into its educational environment. Within the former U.S.S.R., the Baltic states were more IT-active on a per-capita basis than the other republics, although it is not clear to what extent this has continued after independence under difficult economic circumstances. Tunisia is the only Arab country with all four forms of extended internet connectivity (Bitnet, IP, UUCP and Fidonet). Many have no connectivity, e.g., its oil-rich neighbor Libya (4.9 million) which also continues political control of IT. Even with only about 5% telephone penetration (8.2% urban), Tunisia is far ahead of most of the rest of Africa where rates are usually under 1%.

Some dubious niches are also scattered around the world. Bulgaria (8.8 million) seems intent on claiming the "distinction" of generating more computer viruses per computer professional than any other country. Several places—the Cayman Islands (0.03 million), Panama (2.6 million), Cyprus (0.7 million), among others—are suspected of using IT-based financial systems to make national industries of money laundering for global organized crime. The United Arab Emirates (2.7 million) and Paraguay (5 milion) have been major importers of IT equipment in their regions, mostly for the purpose of smuggling to Iran and Brazil, in violation of assorted export or import controls.

What it Takes

The factors that determine a small country's success or failure in IT are not obvious. We have identified a wide range of activities scattered all over the world: in places that have both good and poor geographical locations; in advanced industrialized countries, wealthy newly industrialized economies, and in much less developed nations. Some governments actively promote IT production or use, while others take a hands-off approach. Small size, both geographically and demographically, may be an advantage (e.g., in making it easier to get higher per-capita levels of IT infrastructure built and used). Looking beneath the surface, however, some common characteristics apply to most of the successful countries.

Environment

While these countries vary greatly in level of development, none of them are extremely poor — they average about $11 thousand GDP per capita with none below $1.5 thousand—so some mimimum level of development seems necessary. Most have good basic educational systems (although only a few, e.g., Israel and Sweden, have world class computer research facilities), and high literacy rates. For more advanced IT production and use, specialized skills may be more important than general literacy. Singapore is only in the middle of the pack in Southeast Asia in terms of literacy, but it trained over 10,000 computer professionals during the 1980s as part of its National IT Plan.

The major minors are all operating close to the leading edge in IT use. All have communities that are well connected to the global regime in ways that range from extensive modern telecommunications to the import and export of IT products. Professionals have close ties to the international IT community, host and attend conferences, read journals, and increasingly use the Internet. Although none of these countries have internal markets large enough to support globally competitive sectors on their own, these markets are characterized by world-class, demanding customers who have thus contributed to the creation of substantial export industries.

Production of IT hardware clearly requires integration into the global production chains of the MNCs, which are located in the U.S., Japan and Western Europe. Most countries that have succeeded in this area have favorable geographic locations.

Software production and use is less geography-bound, as programmers can use telecommunications links to customers in the major markets. Software production also benefits from English-language capabilities, either as a native language (New Zealand) or a widely used second language (Israel). This can be explained by the fact that common programming languages are all based on English, that the largest paying markets for software are among the English-speaking countries, and that for various reasons English has become something of a common denominator in the computing world.

However, computing use is spreading rapidly to Chinese-speaking parts of the world, and Hong Kong and Singapore might have advantages in the future. A country such as Costa Rica could likewise become a supplier of Spanish-language software for Spain and Latin America. Another potentially large market for software based on a non-Latin alphabet is among the Arab countries.

IT production and use both benefit from an advanced telecommunications infrastructure. Several of the countries covered are world or regional leaders in the quality of telecommunications infrastructure, enabling them to use computers more productively through networking and to link up to international communities of various kinds. Telecommunications and computers are converging in the development of national information infrastructures (NII), which link computers and provide information services over high-speed communications networks. A high quality NII linked to the developing global information infrastructure (GII) is likely to be a critical competitive factor in the future.

Policy

One key factor is an open policy toward trade and investment. Small countries need to export to reach a sufficient market to support production, especially for hardware. They also need foreign capital, technology and components to support IT production, and low cost foreign hardware and software to permit widespread use. These requirements cannot be met if trade and investment are severely restricted by government policy. An example of the effects of open trade can be seen in New Zealand, which maintained a 40% tariff on imported computers until 1983, when it dropped to 10%. In the ensuing three years, IT investment grew at a rate of 30% a year, as New Zealand rushed to build a more information-oriented economy.

Past policies to develop technological self-sufficiency have been spectacular failures in very large countries including China, Russia and India, and are certainly inappropriate for small countries. Appropriate technology choices for small countries depend on existing technological capabilities and whether one is talking about IT production or use. A developing country might be best served by promoting labor-intensive production activities, such as simple assembly, to produce mature technology products. A higher-wage, technologically sophisticated country will have to compete in IT production by applying more technology- and capital-intensive techniques to more advanced products. The appropriate technology level for broad IT use in most economies is often fairly advanced technologies, because hardware and software continue to become less expensive and easier to use.

Another consideration is government promotion of IT production and use. The clearest example of the potentially powerful effects of government support is seen in Singapore, where since 1981 the government has actively promoted the use of IT in the public and private sectors and has sought investment by foreign IT companies through various incentives. Singapore is the biggest IT producer of and second biggest investor in IT of all the small countries (Table 1). Without government intervention, it is doubtful whether Singapore would have attracted MNCs, developed its own IT industries, or become a regional leader in IT use.

Hong Kong, Denmark and New Zealand have been successful in their own ways with little government support for IT. However, Hong Kong is an exception that proves the rule. Its location and role as an entrepot have given it a temporary advantage which is now being threatened by the rise of Shanghai and the opening of the Chinese economy. Meanwhile Hong Kong's inability to develop indigenous technological capabilities have prevented it from graduating to more advanced manufacturing and R&D activities. New Zealand and Denmark do well as IT users, but are not serious players in the international IT industry.

The governments of Israel and Sweden played major roles in fostering high-tech capabilities in the national defense sectors, with spillover effects. However, at least in the case of Israel the most useful spillover effects, especially in the software industry, were arguably not explicitly government driven. Much of this was in the form of the regular discharge of many young, aggressive, well- trained and experienced people from military service to the civil sectors [1].

More generally, almost all of the more successful countries covered here with serious stakes in the IT industry, owe some significant features of their particular forms of success to government policies. It appears that a laissez-faire policy approach is adequate for the diffusion of IT use, but some forms of active government support seem necessary for a country to become a major IT producer.

As the ability to participate in the international community becomes more dependent on sophisticated IT use and global connectivity, issues of information access become more important. Having an email address is becoming almost as vital to many activities as having a telephone and fax machine. However, allowing access to information sources such as the Internet presents challenges to governments that wish to control information flows in their countries for political reasons. Among the countries discussed here, Singapore has been decried for controlling criticism of its government and the circula-

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tion of some publications, but it is hardly alone in its desire to control information and maintain certain forms of order. Can such countries participate in the global information economy while maintaining domestic control over access to information, or will their political and social cultures have to change to deal with a potential flood of uncontrolled information? ◘

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Readers are encouraged to send comments, anecdotes, insightful speculation, raw data, and articles on subjects relating to international aspects of IT. Correspondence should be addressed to:

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